

# **Solar Turbines Collaborative Projects With Universities**

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## **Introduction**

I am going to talk about the same issues that Sy just mentioned. Believe me, we haven't collaborated. I will start out first by showing you a sample of the AGTSR projects that Solar Turbines is actively collaborating on with various universities and colleges.

## **Collaborative Projects**

Syracuse University is developing an advanced, three-dimensional, viscous, aerodynamic design method for turbo-machinery components that is suitable for application in utility and industrial gas turbines.

Two new projects, which were approved this year, provide funding for (1) the University of California-Davis to conduct an experimental investigation of the three-dimensional flow in the clearance region of cantilevered stator vanes with and without hub rotation; and (2) the Massachusetts Institute of Technology (MIT) to study the impact of end-wall flow and wakes on multistage compressor performance.

To complement our in-house combustion developments, Vanderbilt University is conducting sub-scale testing to verify  $\text{NO}_x$  emission models; the University of California-Berkeley is involved in the development of probes for measuring fuel/air premix concentrations; and Virginia Tech is assisting in the effort to understand the causes for combustion oscillations. This is a problem that has plagued all of us for many years.

We serve on an advisory committee to support the University of Connecticut's efforts to measure stresses and determine the bond strength of thermal barrier coatings. We have provided coated and uncoated specimens to the University of California-Santa Barbara for their evaluation of a mechanism-based approach to life prediction and non-destructive evaluation of thermal barrier coatings.

Although we have done a lot of in-house testing, we are providing funding appointed out of our ATS budget for MIT to study the effect of rotation on screw-shaped vortex cooling of turbine blades. This is additional funding above what they have received to support their related AGTSR project.

The Pennsylvania State University is conducting a study focused on the optimization (reduction) of the penalties associated with the discharge of cooling air. The University of Utah is studying flow and heat transfer phenomena in the swirl chamber of a screw-shaped vortex cooling passage. We expect the University of Utah's project to be completed by the end of the year. Work is ongoing, and the University of Minnesota is collecting data to optimize nozzle end-wall cooling.

## **Student Interns**

I agree with Sy about the value of the Student Intern program. This has been an excellent program for Solar Turbines. It provides excellent training for the student engineers and gives us a chance to assess their capabilities before they graduate. We had 14 interns in 1996. Two of these were sponsored through the AGTSR program and we funded the others. In January of this year, we hired a former intern — a Clemson graduate. He hit the ground running and has done a super job for us.

We try to develop summer projects for the interns where they can start and finish in about 2 1/2 to 3 months. This way, they don't just come in and work on something, but actually accomplish something that they can say they started. In 1997, we had two AGTSR-sponsored interns and a total of 19 student interns. You can see that these interns come to Solar Turbines from colleges and universities all over the country.

In summary, this has been an extremely successful program for Solar Turbines Incorporated. A huge advantage for the interns is that they develop practical skills to supplement their analytical and computer skills. We hope we are bridging the gap between college and industry. We see their immediate contributions when they come to work as permanent employees. They come in with knowledge of our methodology and systems and are ready to go to work. They have developed self-confidence and are real problem solvers.

## **Working With the AGTSR**

The workshops are excellent forums for establishing communications and for providing early feedback to industry. We do not have to wait for final reports, but instead, we talk to people and gather interim results that we can take home and start to apply.

During the first 3 years of the AGTSR program, Solar sent only a few people to the proposal meeting who then had to try to sort through 50 or 60 proposals in a day or a day and a half. That was a lot of work. We now look at the proposals ahead of time, select the managers and engineers who have worked on heat transfer, combustion, or whatever, and send these people to Clemson to go through the proposal selection process.

Prior to that, we spend several days evaluating the proposals and ranking them in each subject category. Knowing that we will be able to fund only about 10 of the 60 or so proposals, we sort through the rankings of the different categories to get an absolute ranking to say of the first 10 or 15. When we walk into Clemson, we have an understanding of what we need and what we think we will be able to fund. We send our experts to the meetings. We have 12 engineers who we specify as points of contact. I believe that all colleges and universities know who those people are.

Indeed, we are heavily involved in the AGTSR program and we are benefiting. For example, the results of AGTSR-sponsored research are starting to influence our gas turbine engine designs, and this research is reflected in the drawings and hardware we are producing today.